Earth Science
FY 2003 Performance Plan

Prologue

The mission of NASA's Earth Science Enterprise (ESE) is to develop a scientific understanding of the Earth system and its response to natural and human-induced changes to enable improved prediction of climate, weather, and natural hazards for present and future generations. NASA brings to this endeavor the vantage point of space, allowing global views of Earth system change. NASA is a provider of objective scientific information, via observation, research, modeling, and applications demonstration, for use by decision-makers in both the public and private sectors. NASA has been studying the Earth from space since inception as an agency. These efforts have led to current and future generations of national weather satellites, and the first series of comprehensive Earth Observing System (EOS) satellites that will concurrently observe for the first time the major interactions of the land, oceans, atmosphere, ice, and life that comprise the Earth system.

We know that natural and human-induced changes are acting on the Earth system. Natural forces include, but are not limited to, variation in the Sun's energy output, and volcanic eruptions, which spew dust into the atmosphere and scatter incoming sunlight. Human forces include deforestation, carbon emission from burning of fossil fuels, methane and soil dust production from agriculture, and ozone depletion by various industrial chemicals. Internal climate factors such as atmospheric water vapor and clouds also introduce feedbacks that serve to either dampen or enhance the strength of climate forcing. We also know the climate system exhibits considerable variability in time and space, i.e., both short and long term changes and regionally specific impacts.

NASA introduced the concept of Earth System Science to promote total understanding of how Earth's atmosphere, biosphere, oceans, and continents shape Earth's climate and its variations. Researchers have constructed computer models to simulate the Earth system, and to explore the possible outcomes of potential changes they introduce in the models. This way of looking at the Earth as a system is a powerful means of understanding changes we see around us. That has two implications for Earth Science. First, we need to ***characterize*** (that is, identify and measure) the forces acting on the Earth system and its responses. Second, we have to ***understand*** the sources of Earth's internal variability: the complex interplay among atmosphere, oceans, continents, and life that comprise the system.

Earth system changes are global phenomena. Yet the system comprises many micro-scale processes and the most significant manifestations are regional. Thus, studying such changes requires a global view at regionally discerning resolutions. This is where NASA comes in, bringing the unique capability to study planet Earth from the vantage point of space. By combining observations, research and modeling, we create a capability to ***predict*** Earth system change to help our partners produce better forecasts of change.

To ***characterize*** the forces acting on the Earth system and its responses, ***understand*** the source of internal variability and ***predict*** Earth system change, NASA must observe the Earth, conduct research and analysis of the data, model the data and synthesize the information into new knowledge. Where we are on this knowledge "life cycle" determines the strategy for our investment decisions.

Implementation Strategy

The baseline ESE program is pursuing a targeted research program, focused on a set of specific science questions that can be addressed effectively with NASA's capabilities. ESE formulates comprehensive research strategies that can lead to definitive scientific answers and to effective applications for the nation.

The key Earth Science research topics sponsored by NASA fall largely into three categories: forcings, responses, and the processes that link the two and provide feedback mechanisms. This conceptual approach applies in essence to all research areas of NASA's Earth Science program, although it is particularly relevant to the problem of climate change, a major Earth Science-related challenge facing our nation and the rest of the world. The ESE has articulated an overarching question and a set of strategic science questions which its observational programs, research and analysis, modeling, and advanced technology activities are directed at answering.

How is the Earth system changing, and what are the consequences for life on Earth?

How is the global Earth system changing?

What are the primary causes of change in the Earth system?

How does the Earth system respond to natural and human-induced changes?

What are the consequences of changes in the Earth system for human civilization?

How can we predict future changes in the Earth system?

In this and subsequent Performance Plans, NASA's annual results in Earth Science will be measured in terms of progress made toward answering these questions. Accordingly, the assessment of performance against the first strategic goal is structured in the form of key questions whose answers are provided by the ongoing mission of NASA's Earth Science program. While these questions will be answered over a period greater than a single year, the general nature of activities in FY 2003 continues to focus on completion of the first EOS satellite series and characterization of the forces acting on the Earth system and its responses. For subsequent plans starting in FY 2004, the Enterprise is developing a set of detailed roadmaps which define the program elements required to achieve answers to these questions and the timing of their achievability. These multiyear roadmaps will then form the basis for future annual performance plans and provide further insight into the ESE longer-term research outcomes.

Research conducted by NASA, within the scope of scientific questions and issues outlined in the ESE Research Strategy, normally follows a well tested process leading from a Principal Investigator (PI) led research activity through periodic publication of interim and final results in the peer reviewed literature, culminating in improved knowledge and/or new technology that can be applied to practical applications involving the solution of contemporary environmental problems of national importance. This process is reflected in our Research Strategy and, as appropriate, in our performance indicators.

The Global Climate Change Act of 1990 specifically highlights the importance of results that apply to the areas of energy and community growth. Given this focus and ESE activities and results in Earth science research and related remote sensing technology development, ESE has recognized the potential to provide socioeconomic benefits in the areas of applying weather forecast optimization to more efficient energy management and to applications in aviation. For example, *USA Today* has noted that the annual cost of electricity could decrease by at least $1B if the accuracy of 30-hour weather forecasts improved 1 degree Fahrenheit. Moreover, the projected annual savings of operating aircraft using NASA developed advanced Synthetic Vision Systems at just 10 airports in the U.S. in one year is estimated to be over $2B. Through existing and planned projects such as Geostationary Imaging Fourier Transform Spectrometer (GIFTS), Shuttle Radar Topography Mission (SRTM), and Earth Observing-1 (EO-1) and our work in atmospheric modeling, climate prediction modeling, topography, and land use/land cover, the ESE will contribute to the potential for such socioeconomic realization in this decade. Earth Science is science in the national interest. NASA is pleased to play a leadership role in exploring and understanding the Earth. This ESE Performance Plan describes our planned accomplishments toward this great scientific endeavor with tangible societal benefits in FY 2003. These planned accomplishments, while important and useful in their own right, are essential stepping-stones on the path to answering the ESE science questions over the next decade.

Characterization of FY 2002 VS FY 2003 Performance Plans

The FY 2003 plan structure, as outlined with its strategic goals and objectives, remains the same as that in the FY 2002 plan. The indicators of progress are the only elements that have changed. This year, we have only developed detailed indicators for one-third of our basic research portfolio. However a qualitative assessment will be provided on progress made in every science question in the FY 2003 report. In future years, we will assess progress against the road maps we are developing for our entire research portfolio.

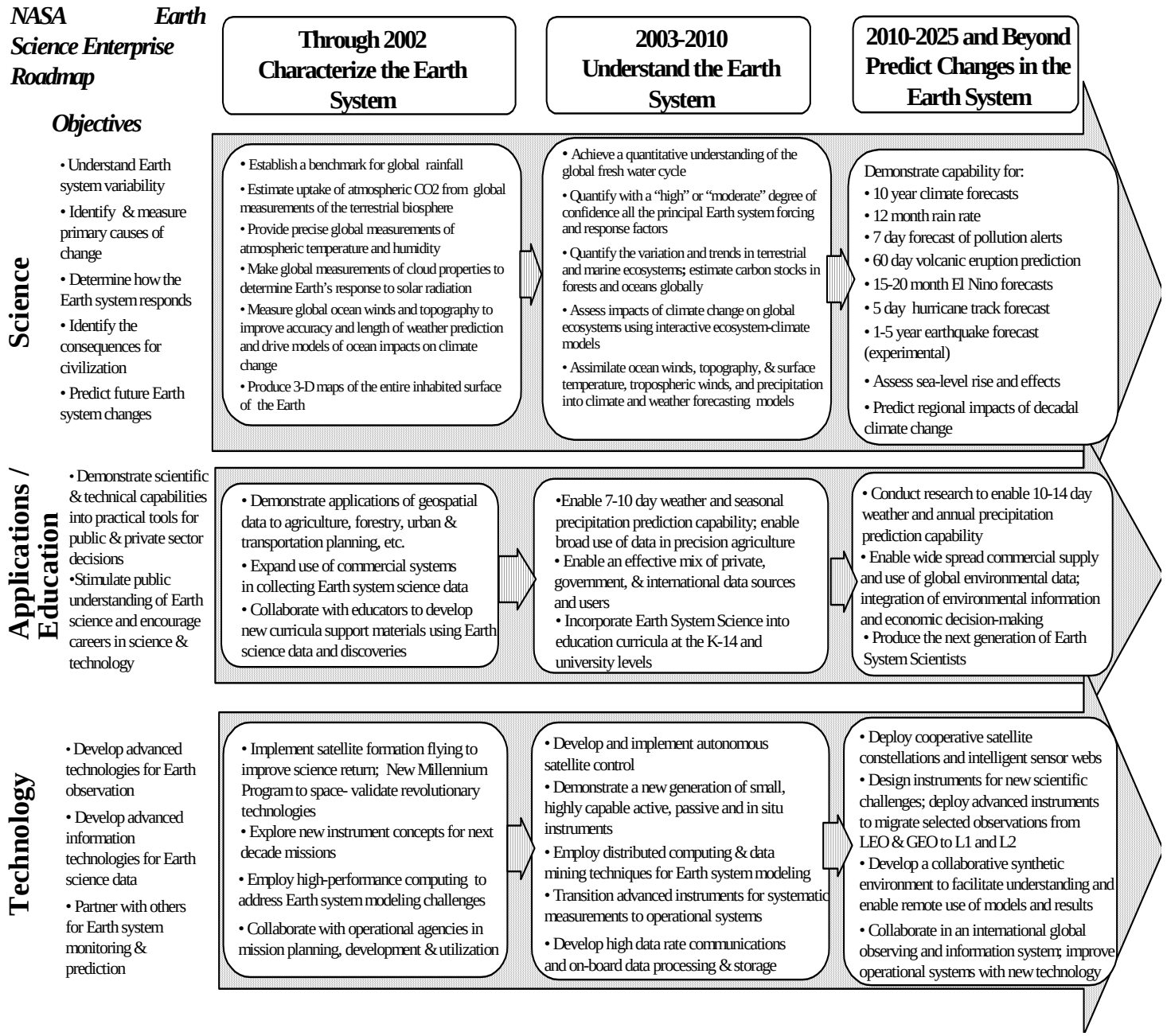
NASA Earth Science Enterprise Roadmap
Through 2002 Characterize the Earth System
2003-2010 Understand the Earth System
2010-2025 and Beyond Predict Changes in the Earth System
Objectives
Science
• Understand Earth system variability
• Identify & measure primary causes of change
• Determine how the Earth system responds
• Identify the consequences for civilization
• Predict future Earth system changes
• Establish a benchmark for global rainfall
• Estimate uptake of atmospheric CO2 from global measurements of the terrestrial biosphere
• Provide precise global measurements of atmospheric temperature and humidity
• Make global measurements of cloud properties to determine Earth's response to solar radiation
• Measure global ocean winds and topography to improve accuracy and length of weather prediction and drive models of ocean impacts on climate change
• Produce 3-D maps of the entire inhabited surface of the Earth
• Achieve a quantitative understanding of the global fresh water cycle
• Quantify with a "high" or "moderate" degree of confidence all the principal Earth system forcing and response factors
• Quantify the variation and trends in terrestrial and marine ecosystems; estimate carbon stocks in forests and oceans globally
• Assess impacts of climate change on global ecosystems using interactive ecosystem-climate models
• Assimilate ocean winds, topography, & surface temperature, tropospheric winds, and precipitation into climate and weather forecasting models
Demonstrate capability for:
• 10 year climate forecasts
• 12 month rain rate
• 7 day forecast of pollution alerts
• 60 day volcanic eruption prediction
• 15-20 month El Nino forecasts
• 5 day hurricane track forecast
• 1-5 year earthquake forecast (experimental)
• Assess sea-level rise and effects
• Predict regional impacts of decadal climate change
Applications / Education
• Demonstrate scientific & technical capabilities into practical tools for public & private sector decisions
•Stimulate public understanding of Earth science and encourage careers in science & technology
• Demonstrate applications of geospatial data to agriculture, forestry, urban & transportation planning, etc.
• Expand use of commercial systems in collecting Earth system science data
• Collaborate with educators to develop new curricula support materials using Earth science data and discoveries
•Enable 7-10 day weather and seasonal precipitation prediction capability; enable broad use of data in precision agriculture
• Enable an effective mix of private, government, & international data sources and users
• Incorporate Earth System Science into education curricula at the K-14 and university levels
• Conduct research to enable 10-14 day weather and annual precipitation prediction capability
• Enable wide spread commercial supply and use of global environmental data; integration of environmental information and economic decision-making
• Produce the next generation of Earth System Scientists
Technology
• Develop advanced technologies for Earth observation
• Develop advanced information technologies for Earth science data
• Partner with others for Earth system monitoring & prediction
• Implement satellite formation flying to improve science return; New Millennium Program to space- validate revolutionary technologies
• Explore new instrument concepts for next decade missions
• Employ high-performance computing to address Earth system modeling challenges
• Collaborate with operational agencies in mission planning, development & utilization
• Develop and implement autonomous satellite control
• Demonstrate a new generation of small, highly capable active, passive and in situ instruments
• Employ distributed computing & data mining techniques for Earth system modeling
• Transition advanced instruments for systematic measurements to operational systems
• Develop high data rate communications and on-board data processing & storage
• Deploy cooperative satellite constellations and intelligent sensor webs
• Design instruments for new scientific challenges; deploy advanced instruments to migrate selected observations from LEO & GEO to L1 and L2
• Develop a collaborative synthetic environment to facilitate understanding and enable remote use of models and results
• Collaborate in an international global observing and information system; improve operational systems with new technology

Figure 1. Strategic Roadmap for the Earth Science Enterprise

Resource Requirements:

	FY 1999*	FY 2000*	FY 2001*	FY 2002	FY 2003
$ in M	1,414	1,443	1,485	1,626	1,628
Civil Service FTE	1,365	1,907	1,913	1,747	1,848

* Two-appropriation structure starts in FY 2002.

FY 2003 Performance Measures

Enterprise Mission: Develop a scientific understanding of the Earth system and its response to natural and human-induced changes to enable improved prediction of climate, weather, and natural hazards for present and future generations.

NASA's ESE is dedicated to understanding the total Earth system and the effects of natural and human-induced changes on the global environment. The vantage point of space provides information about Earth's land, atmosphere, ice, oceans, and biota that is obtainable in no other way. Programs of the ESE study the interactions among these components to advance the new discipline of Earth System Science. Our research results contribute to the development of sound environmental policy and economic investment decisions**.**

NASA's ESE also develops innovative technologies and applications of remote sensing for solving practical societal problems in agriculture and food production, natural hazard mitigation, water resources, regional planning, and national resource management in partnership with other Federal agencies, with industry, and with state and local governments. Earth Science discoveries are shared with the public to enhance science, mathematics, and technology education and increase the scientific and technological literacy of all Americans. ESE combines the excitement of scientific discovery with the reward of practical contribution to the sustainability of planet Earth.

Strategic Goal: Observe, understand, and model the Earth system to learn how it is changing, and the consequence for life on Earth.

NASA's Earth observing and research program elements are the principal means by which global-scale questions about our home planet are posed and answered. These elements identify the variability in the Earth system, the forces responsible for change, responses of the Earth system to changes, and the consequences and predictability of future change. Nations and industries make billions of dollars worth of investment decisions yearly that will be better informed by the information and understanding we provide.

Objective: Discern and describe how the global Earth system is changing.

Annual Performance Goal (3Y1). Increase understanding of global precipitation, evaporation and how the cycling of water through the Earth system is changing.

It is important to establish a baseline for determining the existence or absence of significant trends in the water cycle, and the extent to which observed changes match predictions. Acceleration of the global water cycle could result in intensification and/or redistribution of rainfall patterns, severe storm frequency, droughts and glacial melting. Understanding of the water cycle enables prediction of freshwater availability.

The last set of indicators and associated progress was presented in the FY 2002 performance plan. We did not develop specific indicators for FY 2003. An assessment of progress toward answering this question will be published in the FY 2003 report.

Annual Performance Goal (3Y2). Increase understanding of global ocean circulation and how it varies on interannual, decadal, and longer time scales.

Establishing the basis for variations in the temperature and circulation of the upper ocean can be used to help assess any changes that may be affecting the Earth's weather and climate, including EL Niño phenomena.

Performance Indicator: Update the record of trends in sea ice duration, concentration and extent to span the period from 1979-2000. Current records extend to 1996.

Performance Indicator: Initiate production of sub-monthly analysis from a data-assimilating global ocean model, using NASA and other agency satellite and *in situ* observations, to evaluate ocean circulation changes such as those associated with EL Niño. This work is done in the context of the Global Ocean Data Assimilation Experiment. [http://www.ecco.ucsd.edu/]

Annual Performance Goal (3Y3). Increase understanding of global ecosystems change.

The activity establishes the basis for short-term, seasonal, and inter-annual variability of ecosystems. It also provides a baseline against which to evaluate future change. Measurements of seasonal, annual, and inter-annual changes in ecosystems are used to estimate productivity in agriculture, forestry, fisheries, and Earth's unmanaged lands and oceans.

The last set of indicators and associated progress was presented in the FY 2002 performance plan. We did not develop specific indicators for FY 2003. An assessment of progress toward answering this question will be published in the FY 2003 report.

Annual Performance Goal (3Y4). Increase understanding of stratospheric ozone changes, as the abundance of ozone-destroying chemicals decreases and new substitutes increases by meeting 2 of 2 performance indicators.

Reduction in atmospheric ozone amounts leads to an increased flux of ultraviolet radiation at the Earth's surface, with harmful effects on plant and animal life including human health. Understanding and possibly mitigating this process is a key ESE concern.

> Performance Indicator: Provide continuity of calibrated data sets from ground-based, suborbital, and space-based instruments for determining long term trends in the total column and profile abundances of stratospheric ozone with sufficient precision to enable the later assessment of expected ozone recovery.
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> Performance Indicator: Characterize the inter-annual variability and possible long-term evolution of stratospheric aerosols (characteristics and profile abundances) and of the vertical profiles of methane, water vapor, and temperature to assist in the interpretation of observed ozone changes and chemistry-climate interactions. This requires a combination of data records from ground-based, airborne, balloon-borne, and space-based measurements.

Annual Performance Goal (3Y5). Increase understanding of change occurring in the mass of the Earth's ice cover by meeting at least 3 of 4 performance indicators.

Sea level is estimated to have been rising by as much as 2 mm/year over the last century. Possible contributions to this change include thermal expansion of the oceans and the loss of ice from glaciers and the large ice sheets. Of these, the large ice sheets present the greatest uncertainty in terms of their contribution to sea level rise and also represent the greatest potential threat to the coastal ecosystems and infrastructure. It is therefore important to establish whether Polar Regions are in the process of losing mass and contributing to the current observed sea level rise.

> Performance Indicator: Convert remotely sensed observations of Greenland ice sheet surface melting to estimates of ice mass loss in order to quantify how much ice is lost to melting, and its variability from year to year.
>
> Performance Indicator: Produce the first high-resolution (~10-15m) synthetic aperture radar "mini-mosaics" for key coastal regions in Antarctica to be used as a baseline for comparison to past and present high-resolution imagery.
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> Performance Indicator: Use initial ICESat elevation data in Greenland and Antarctica to determine a baseline elevation for regions measured.

Performance Indicator: Perform initial assessment of the extent to which sea ice thickness can be determined using ICESat.

Annual Performance Goal (3Y6). Increase understanding of the motions of the Earth, the Earth's interior, and what information can be inferred about the Earth's internal processes.

Motions of the Earth's Interior are the forcings, which drive earthquakes, volcanoes, and build our mountains and valleys. Knowledge, which has been building over the past decades, has led to a quantum leap in our understanding of how our planet has evolved. Through this new knowledge has come a better understanding of natural hazards and natural resource assessment. Technological by-products include better navigation (including civilian Global Positioning System (GPS), the tracking of ocean height variability, and the attendant visualization of EL Niño and related phenomena to name just a few of many applications.

The last set of indicators and associated progress was presented in the FY 2002 performance plan. We did not develop specific indicators for FY 2003. Progress toward answering this question will be published in the FY 2003 report.

Objective: Identify and measure the primary causes of change (forcings) in the Earth system.

Annual Performance Goal (3Y7). Increase understanding of trends in atmospheric constituents and solar radiation and the role they play in driving global climate by meeting at least 4 of 5 performance indicators.

Solar radiation is the primary external force acting on Earth's climate. Atmospheric constituents, clouds, and aerosols drive the climate system; changes in their concentration/distribution will contribute to climate change through a variety of processes.

Performance Indicator: Continue and extend the current 23-year record of concentration measurements (and associated standards development) of anthropogenic and naturally occurring halogen-containing chemicals and other chemically active and greenhouse gases to provide for an understanding of future changes in ozone and climate forcing.

Performance Indicator: Characterize global sources of carbon monoxide using data assimilation techniques to combine carbon monoxide measurements from Measurements of Pollution in the Troposphere (MOPITT) with chemical transport models.

Performance Indicator: Use the comprehensive multi-instrument integrated data set for studying the sources/sinks and distribution of tropospheric aerosols over land, based on data from the Total Ozone Mapping Spectrometer (TOMS), Moderate Resolution Imaging Spectro Radiometer (MODIS),

and Multi-angle Imaging Spectroradiometer (MISR) instruments to support evaluation of the impact on climate forcing of natural and anthropogenic aerosols in the atmosphere.

Performance Indicator: Combine multiple instrument data sets on the total solar irradiance (i.e. the total solar radiation per unit of Earth surface) and the solar ultraviolet (UV) flux (i.e. the UV component of total solar irradiance) over a full solar cycle in order to explore correlations between solar variation and climate without resorting to solar proxies (i.e. indirect measures of solar variability).

Performance Indicator: Reduce uncertainty (i.e. error) in the retrievals (calculation) of upper troposphere / lower stratosphere water vapor abundances (from microwave soundings) by 10 – 30% through improved laboratory spectroscopic measurements of the water vapor continuum.

Annual Performance Goal (3Y8). Increase understanding about the changes in global land cover and land use and their causes.

Change in land cover and land use is the dominant present-day forcing of change in terrestrial and coastal ecosystems and constitutes our largest uncertainty in the global carbon budget. Understanding the human and biophysical factors that cause land cover and land use change will be essential for assessing consequences for food production, natural resources availability, and resource management as well as for predicting future global changes.

The last set of indicators and associated progress was presented in the FY 2002 performance plan. We did not develop specific indicators for FY 2003. Progress toward answering this question will be published in the FY 2003 report.

Annual Performance Goal (3Y9). Increase understanding of the Earth's surface and how it is transformed and how such information can be used to predict future changes.

This effort is leading to a better understanding of natural events/processes that transform or change the topographic surface of the Earth, and the impact of such changes on human activities. Progress toward answering this question will lead to a better understanding of the risk of natural hazards and societies vulnerability to natural disasters. By products of these activities include better topographic maps of the Earth surface. These are important to many endeavors such as airplane landing and routing, watershed assessment, and roadway planning. Risk assessment for natural hazards such as flooding, earthquakes, landslides, and volcanoes is becoming increasingly important as societal resources are developed and concentrated in vulnerable areas.

The last set of indicators and associated progress was presented in the FY 2002 performance plan. We did not develop specific indicators for FY 2003. Progress toward answering this question will be published in the FY 2003 report.

Objective: Determine how the Earth system responds to natural and human-induced changes.

Annual Performance Goal (3Y10). Increase understanding of the effects of clouds and surface hydrologic processes on climate change.

It is important to establish a basis for determining the vertical distribution and optical properties of cloud particles to provide measurement-based estimates of atmospheric heating rather than relying on climatological statistics or models. Clouds are the most important factor that controls the Earth's radiation balance, which, along with evaporation and condensation of atmospheric and surface water, drives the major weather systems. Thus, determining the vertical distribution and optical properties of cloud particles will ultimately lead to better climate predictions. Soil moisture is an important land surface state variable, currently unmeasured at large spatial scales that also affects weather and climate.

The last set of indicators and associated progress was presented in the FY 2002 performance plan. We did not develop specific indicators for FY 2003. Progress toward answering this question will be published in the FY 2003 report.

Annual Performance Goal (3Y11). Increase understanding of how ecosystems respond to and affect global environmental change and affect the global carbon cycle.

Today, Earth's ecosystems are experiencing multiple, interacting, changing environmental conditions, and it will be vitally important to understand the implications of their responses, including some that may surprise us, for sustained agriculture, forestry, and fisheries, and for the continued provision of ecosystem goods and services that are valuable to human societies. We also need to know how their responses provide feedback to the atmosphere through fluxes of water, energy, and trace gases. Most importantly, we must develop understanding of the past, present, and future role of ecosystems as sources and sinks of carbon and in regulating the global carbon cycle.

The last set of indicators and associated progress was presented in the FY 2002 performance plan. We did not develop specific indicators for FY 2003. An assessment of progress toward answering this question will be published in the FY 2003 report.

Annual Performance Goal (3Y12). Increase understanding of how climate variations induce changes in the global ocean circulation by meeting at least 2 of 3 performance indicators.

Ocean circulation patterns strongly influence regional climates, yet these are known to have exhibited variability. For example, circulation associated with the global "conveyor" belt, including the Gulf Stream, provides for the relatively mild climate of northern Europe. Changes in such large-scale ocean circulation could significantly impact the habitability of this region in particular.

Performance Indicator: Use diagnostic analysis of seasonal and interannual variability induced in the interior ocean based on Seawinds high-resolution ocean winds to evaluate improvements in climate and marine weather forecasting. (Ocean Surface Vector Winds Science Team http://winds.jpl.nasa.gov).

Performance Indicator: Use near decade-long sea surface topography and in situ upper-ocean temperature profile measurement time series to develop a high resolution Pacific Ocean model to elucidate the mechanisms of the Pacific Decadal Oscillation and its impact on seasonal/decadal climate variations [http://decvar.org].

Performance Indicator: Utilize space-based Ocean Topography time series, in situ observations of the World Climate Research Program, and assimilation of these data into ocean models to ascertain whether detectable changes in the deep ocean have occurred over the last decade.

Annual Performance Goal (3Y13). Increase understanding of stratospheric trace constituents and how they respond to change in climate and atmospheric composition.

Stratospheric composition, most importantly amounts of UV-absorbing ozone, responds to concentrations of chemically active trace gases and underlying meteorological conditions, such as temperature and wind distributions. Changing atmospheric conditions associated with global chemical change (and associated global warming) have the potential to affect the stratosphere, which can in turn affect fluxes of biologically damaging UV radiation at the Earth's surface.

Performance Indicator: Utilize combined data sets from ground-based, sub-orbital, and space-based measurements to assess the possible impact of the increased abundances of greenhouse gases on the future evolution of Northern Hemisphere high latitude ozone concentrations. This will include extended analysis of data from the SAGE III Ozone Loss and Validation Experiment (SOLVE).

Performance Indicator: Quantify the relationship between wintertime tropospheric wave energy and late winter temperatures in the Arctic lower stratosphere in order to analyze the effects of changing tropospheric weather patterns on Arctic ozone chemistry.

Annual Performance Goal (3Y14). Increase understanding of global sea level and how it is affected by climate change.

The polar ice sheets are a repository for about 75% of the Earth's fresh water and a reduction in their combined mass of just 1% would increase sea level by about 90 cm. Of the order of 100 million people would be at direct risk from a sea level rise of this magnitude (Intergovernmental Panel on Climate Change (IPCC), 1995) and many more would be indirectly affected through economic and other impacts. It is therefore important to establish whether the ice sheets have the potential, under climate change scenarios, to exhibit major changes in mass balance and if so, what the expected time-scale for such changes would be.

Performance Indicator: Compare remotely sensed discharge fluxes of ten outlet glaciers in Antarctica to estimates based on balance velocities to determine the basin mass balance, which will provide an assessment of how major outlet glaciers contribute to sea level rise.

Performance Indicator: Initiate development of improved models of outlet glacier flow characteristics that will assess nature of discharge and sensitivity to climate changes, which will improve prediction capabilities of sea level rise from ice sheet dynamics.

Annual Performance Goal (3Y15). Increase understanding of the effects of regional pollution on the global atmosphere, and the effects of global chemical and climate changes on regional air quality by meeting at least 4 of 5 performance indicators.

There is significant evidence that pollutant gases can be transported over very long distances (e.g., across the Pacific or Atlantic oceans). The global effects of atmospheric pollution (on agriculture, materials, human health, etc.) are poorly known due to inexact characterization of tropospheric transport, physics, and chemistry.

Performance Indicator: Continue and extend the four-year data record of tropical ozone soundings in order to establish a climatology (i.e. the natural pattern/cycle of ozone) of the high-resolution vertical distribution of ozone (i.e. the concentration at each altitude) in the tropics, leading to improved retrievals of tropospheric ozone concentrations from space-based measurements.

Performance Indicator: Characterize the atmospheric plume from East Asia and assess its contribution to regional and global atmospheric chemical composition by completing the archival of the Transport of Chemical Evolution over the Pacific (TRACE-P) airborne mission and associated data sets, which will improve the assessment of intercontinental transport of pollution.

Performance Indicator: Update the estimate of the tropospheric distributions and possible trends of hydroxyl (OH) radicals and examine the consistency between different model types (i.e. inverse and

assimilation) in determining global OH fields using multiple data sets, which will allow assessment of the atmosphere's capacity for self-cleansing.

Performance Indicator: Continue development and testing of a coupled aerosol-chemistry-climate general circulation model to project future changes in atmospheric composition over the 21st century. This model, which will include first-time parameterization of tropospheric aerosol chemistry, will help to diagnose the climatic consequences of these emissions and the associated feedbacks on atmospheric composition.

Performance Indicator: Improve estimates of the stratospheric contribution to tropospheric ozone through chemical transport models. The stratosphere-troposphere exchange included in these model calculations will be examined for its sensitivity to global warming.

Objective: Identify the consequences of change in the Earth system for human civilization.

Annual Performance Goal (3Y16). Increase understanding of variations in local weather, precipitation, and water resources and how they relate to global climate variation.

This activity establishes a basis for determining what changes will be induced by climate trends in the frequency, strength, and path of weather systems, which produce clouds and rain which replenish fresh water supplies.

The last set of indicators and associated progress was presented in the FY 2002 performance plan. We did not develop specific indicators for FY 2003. An assessment of progress toward answering this question will be published in the FY 2003 report.

Annual Performance Goal (3Y17) Increase understanding of the consequence of land cover and land use change for the sustainability of ecosystems and economic productivity.

Today, land cover, and land use changes are primarily due to human activities, and are most prevalent where human populations are large; thus the consequences of land cover and land use change impact our daily lives and the potential sustainability of food production, natural resource use, and environmental quality. Consequences of concern include changes in carbon sources and sinks; the loss of biodiversity; inputs of sediments, nutrients, and pollutants to coastal regions; land degradation, and increased risks to human health.

The last set of indicators and associated progress was presented in the FY 2002 performance plan. We did not develop specific indicators for FY 2003. An assessment of progress toward answering this question will be published in the FY 2003 report.

Annual Performance Goal (3Y18). Increase understanding of the consequences of climate and sea level changes and increased human activities on coastal regions.

The consequences of global environmental change are often seen in the coastal zone. Human populations are concentrated near coastlines, and there are severe impacts on coastal communities from pollution, excess nutrients, storm-surge, and sea-level rise. It will be important to understand the relative contributions of each of these factors to the overall changes in coastal regions, and especially, their effect on the resident human communities.

The last set of indicators and associated progress was presented in the FY 2002 performance plan. We did not develop specific indicators for FY 2003. An assessment of progress toward answering this question will be published in the FY 2003 report.

Objective: Enable the prediction of future changes in the Earth system.

Annual Performance Goal (3Y19). Increase understanding of the extent that weather forecast duration and reliability can be improved by new space-based observations, data assimilation, and modeling.

This activity contributes to improving the accuracy of short-term weather predictions and increasing the period of validity of long-range forecasts that are used by government, business, and individuals to protect lives and property and make investment decisions.

The last set of indicators and associated progress was presented in the FY 2002 performance plan. We did not develop specific indicators for FY 2003. An assessment of progress toward answering this question will be published in the FY 2003 report.

Annual Performance Goal (3Y20). Increase understanding of the extent that transient climate variations can be understood and predicted

This activity contributes to the ability to predict global and regional climate on seasonal-to-interannual time scales with sufficient accuracy for concerned socioeconomic interests to estimate the likely impact of climate variations, such as those associated wit EL Niño /La Nina, and to issue warnings and make appropriate contingency plans. NASA will endeavor to transition the results of this research to those public agencies that have operational planning and warning responsibilities. In addition, NASA will also make the results available to concerned interests in the private sector.

The last set of indicators and associated progress was presented in the FY 2002 performance plan. We did not develop specific indicators for FY 2003. An assessment of progress toward answering this question will be published in the FY 2003 report.

Annual Performance Goal (3Y21). Increase understanding of the extent that long-term climate trends can be assessed or predicted.

This activity will provide information needed to determine policies for possible mitigation of, or adaptation to, climate change. Specifically, it will provide information on the causes of recent and current climate changes as well as the expected magnitude and causes of future climate trends including the nature of regional climate changes. An integral part of this research is an assessment of the reliability of climate predictions and how alternative assumptions and policies affect them.

> The last set of indicators and associated progress was presented in the FY 2002 performance plan. We did not develop specific indicators for FY 2003. An assessment of progress toward answering this question will be published in the FY 2003 report.

Annual Performance Goal (3Y22). Increase understanding of the extent that future atmospheric chemical impacts on ozone and climate can be predicted by meeting at least 2 of 3 performance indicators.

A sound scientific basis is essential for informed decision making at the national and international level on environmental issues that underlie human health and well being as well as the health of the numerous ecosystems. Only through the integration of science and policy, as occurred effectively through the assessment process (for example the various assessment panels associated with the Montreal Protocol), can the sustainable development of our Nation be insured.

> Performance Indicator: Analyze the measured trends in atmospheric trace gas concentrations using updated data sets and compare the results with those estimated from industrial production and emission data. The analysis will be used to assess the completeness of our understanding of the atmospheric persistence and degradation of industrial chemicals as well as to examine the efficiency of current regulatory agreements and international reporting on the production and emissions of regulated chemicals. Provide the results of such analyses for inclusion in the next international Assessments of Stratospheric Ozone Depletion.
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> Performance Indicator: Perform laboratory studies designed to assess the atmospheric fate of industrial and naturally occurring chemicals by characterizing the key photochemical processes responsible for their atmospheric breakdown.
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> Performance Indicator: Complete the implementation of the Global Modeling Initiative (GMI) to provide metrics, benchmarks, and controlled numerical experiments for model and algorithm simulations performance, which will allow the development of standards of model behavior for participation in national/international assessments.

Annual Performance Goal (3Y23). Increase understanding of the extent that future concentrations of carbon dioxide and methane and their impacts on climate can be predicted.

A sound scientific basis is essential for informed decision making at the national and international level on environmental issues that relate to the Earth's future climate and underlie human health and well being as well as the health of the numerous ecosystems. Only through the integration of science and policy, as occurred effectively through the assessment process (for example the various assessment panels associated with the Montreal Protocol), can the sustainable development of our Nation be insured.

The last set of indicators and associated progress was presented in the FY 2002 performance plan. We did not develop specific indicators for FY 2003. An assessment of progress toward answering this question will be published in the FY 2003 report.

Strategic Goal: Expand and accelerate the realization of economic and societal benefits from Earth science, information, & technology.

Scientific data must be transformed into information products useful to non-scientists in order for the economy and society to realize the full benefit of it. Our applications and education programs are designed to achieve this end through partnerships between NASA and professional information product providers and educators. The accomplishment of the identified performance indicators will enable the user community to accomplish their day-to-day decision-making in a more effective manner resulting in either cost savings, improved timeliness or quality, or to accomplish tasks that were not previously possible with conventional means. The accomplishment of the performance indicators will enable the U.S. taxpayer to reap the potential socio-economic benefits of NASA's investment in Earth science and technology.

Objective: Demonstrate scientific and technical capabilities to enable the development of practical tools for public and private sector decision-makers.

Annual Performance Goal (3Y24): Provide regional decision-makers with scientific and applications products and tools.

Increased application of and access to ESE science and technology results will enable the Nation to reap significant benefits in the areas of community growth and infrastructure, disaster management, environmental assessment, and resource management. The performance indicators are aimed at measuring: (a) the identification of the most significant needs in the federal, state, local, and tribal government community that can benefit from these results; (b) the development of new and advanced applications as well as related methods and practices in cooperation with the user community; and (c) the demonstration and distribution of these results to the targeted users. The accomplishment of the identified target indicators and related application activities will enable the user community to accomplish their day-to-day decision-making in a more effective and efficient manner resulting in either cost savings, improved timeliness or quality, or in

an ability to accomplish tasks that were not previously possible with conventional means. The accomplishment of the performance indicators will enable the U.S. taxpayer to reap the potential socio-economic benefits of NASA's investment in Earth science and technology.

Performance Indicator: Identify at least 2 common information requirements that address the Applications Program's constituencies' user needs and develop plans that will address those requirements and successfully move applications in those areas toward operational use.

Performance Indicator: Verify and validate technology, algorithms, and scientific results in partnership with selected commercial partners. Fully verify and validate at least 2 demonstration products that meet program priorities.

Performance Indicator: Plan, implement and/or manage twenty demonstration projects by the end of FY 2003 in cooperation with state, local, and tribal decision-makers. The progress of each project towards full implementation and adoption by the end users will be measured systematically.

Objective: Stimulate public interest in and understanding of Earth system science and encourage young scholars to consider careers in science and technology.

Annual Performance Goal (3Y25): Share the excitement of NASA's scientific discoveries and the practical benefits of Earth science to the public in promoting understanding of science and technology in service to the society. Success will equate to meeting 3 of 4 performance indicators.

Increased public awareness and understanding of how the Earth functions as a system and increased literacy in Earth science and technology will result in attracting the next generation of scientists and engineering students to pursue their degrees in Earth system science. This will build capacity for productive use of Earth science information in resolving everyday practical problems.

Performance Indicator: Sponsor 2-3 leading undergraduate institutions to develop courses that enable pre-service science educators to become proficient in Earth system science and in using NASA remotely sensed observations in such curriculum.

Performance Indicator: Work with at least one professional organization to develop content guidelines for professional practice of Earth remote sensing and geospatial data.

Performance Indicator: Provide, in public venues, at least 2-3 stories per month that cover scientific discoveries, practical benefits or new technologies sponsored by NASA's Earth science program.

Performance Indicator: Continue to train a pool of highly qualified scientists and educators in Earth science and remote sensing by sponsoring approximately 140 graduate fellowships (approximately 1/3 each in their first, second and third year) and approximately 25-30 New Investigator awards per year to recent Ph.D. recipients.

Strategic Goal: Develop and adopt advanced technologies to enable mission success and serve national priorities.

New and less costly remote sensing capabilities are made possible by targeted investment in advanced technologies. These technologies will make possible the next generation of weather, climate, and Earth systems monitoring satellites. They will leverage advances in information technologies to make vast quantities of Earth science data useful and accessible to scientists, practitioners, and the public.

Objective: Develop advanced technologies to reduce the cost and expand the capability for scientific Earth observation.

Annual Performance Goal (3Y26): Successfully develop and infuse technologies that will enable future science measurements, and/or improve performance as well as reduce the cost of existing measurements. Increase the readiness of technologies under development, retiring risks, and advancing them to a maturity level where they can be infused into new missions with shorter development cycles. Success will equate to meeting 3 of 4 performance indicators.

New space-based technologies enable measurements that were not previously possible. Often, these measurements support new Earth-science research activities from the vantage point of space and enable monitoring that leads to early warnings to the public of natural hazards (ozone, fire, flood, earthquake, and volcano threats) or life threatening weather conditions. Alternatively, many new technologies reduce the cost of existing measurements while improving their quality. Predictive information can be generated for the public with more reliability, at lower cost, with delivery to users in a shorter period.

A key enabler for advanced technology infusion is space flight validation where the risk to the first uses is perceived to be high, but the payoff to science and applications is high. Consequently, space flight validation of breakthrough technologies to enable high priority future science measurement capabilities is an integral part of the technology infusion strategy.

Advanced information system capabilities will enable increased on-board autonomy for space-based assets, new levels of performance for ground-based analysis, and simulation of Earth-system processes towards making available such information to users in a timely and affordable fashion.

Performance Indicator: Annually advance 25% of funded technology developments by one Technology Readiness Level (TRL).

Performance Indicator: Annually mature at least three (3) technologies to the point where they can be validated in space or incorporated directly into a science and/or operational project(s).

Performance Indicator: Annually infuse at least one (1) technology development to a commercial entity; into a remote sensing or in-situ project; or into the ESE information systems infrastructure.

Performance Indicator: Annually establish at least one (1) joint agreement with a program external to NASA's ESE that results in the inclusion of at least one new ESE technology requirement.

Objective: Develop advanced information technologies for processing, archiving, accessing, visualizing, and communicating Earth science data.

Annual Performance Goal (3Y27): Develop hardware/software tools to demonstrate high-end computational modeling to further our understanding and ability to predict the dynamic interaction of physical, chemical, and biological processes affecting the earth. Success will equate to meeting 2 of 3 indicators.

Advanced computational capabilities support deployment of increasingly complex observation systems; higher quality, more refined characterization of Earth-system processes; accurate longer-range predictions of natural hazards and life threatening weather conditions; and near real-time delivery of data and information to users.

Performance Indicator: Successfully demonstrate networked high performance computer for Earth science modeling challenges.

Performance Indicator: Publish software libraries that enable climate models to scale to at least 512 nodes on a high performance computer cluster.

Performance Indicator: Demonstrate quasi-operational usage of a high performance computer with a throughput of at least 30 days/day of data assimilation.

Performance Indicator: Successfully demonstrate an increase in sustained high-end computing performance over the present level of 100 gigaflops. Additional scenarios of climate change simulations and the model sensitivities to the parameterizations can be assessed with the increased sustained performance.

Annual Performance Goal (3Y28): Develop baseline suite of multidisciplinary models and computational tools leading to scalable global climate simulations.

Performance Indicator: Successfully demonstrate up to three Earth science modeling codes interoperating on a functioning Modeling Framework early prototype. (A Modeling Framework means

the existence of a consistent pre-defined interface between different model components. The model components are swappable and interchangeable between different models if these models follow the same framework design.)

Performance Indicator: Demonstrate a doubling of performance over FY 2002 in at least one (1) suite of multidisciplinary models or computational tool sets that support the Earth Science Research Strategy.

Objective: Partner with other domestic and international agencies to develop and implement better methods for using remotely sensed observations in Earth system monitoring and prediction.

The challenges of Earth System Science and its applications including sustainable development, and mitigation of risks to people, property, and the environment from natural disasters, require collaborative efforts among a broad range of domestic and international partners. This cooperation provides significant benefits to NASA's ESE through the pooling of financial resources, access to unique domestic and foreign capabilities including infrastructure and expertise, increases in mission flight opportunities and enhances the overall scientific return.

Annual Performance Goal (3Y29): Collaborate with other domestic and international agencies in developing and implementing better methods for using remotely sensed observations to support national and international assessments of climate changes and their practical consequences. Success will equate to meeting 4 of 5 performance indicators.

Performance Indicator: Continue collaborative relations with such Federal agencies as the U.S. Department of Transportation (DOT), the U.S. Department of Commerce (DOC), the Federal Aviation Administration (FAA), the U.S. Geological Survey (USGS), the U.S. Department of Agriculture (USDA) and the Environmental Protection Agency (EPA) to promote the use of remotely sensed data and information to accomplish U.S. strategic scientific, environmental and economic objectives.

Performance Indicator: Continue to identify and establish international cooperation with international agencies to promote the use of remotely sensed data and information to accomplish U.S. strategic scientific, environmental, and economic objectives.

Performance Indicator: Demonstrate enhanced interoperability and interconnectivity of international remote sensing information systems and services through NASA's participation in the Committee on Earth Observation Satellites (CEOS) Working Group on Information Systems and Services.

Performance Indicator: Demonstrate enhanced mission coordination and complementarity of remote sensing data through NASA's participation in the CEOS Working Group on Calibration and Validation.

Performance Indicator: Demonstrate the establishment of an agreed international approach to an integrated global observing strategy for the oceans and the terrestrial carbon cycle through participation in the Integrated Global Observing Strategy - Partners (IGOS-P).

Enterprise-Wide Activities that enable achievement of Earth Science strategic goals.

Annual Performance Goal (3Y30): Successfully develop one (1) spacecraft and have ready for launch. Operate instruments on orbiting spacecraft to enable Earth Science research and applications goals and objectives.

Performance Indicator: Successfully develop and have ready for launch at least one spacecraft.

Performance Indicator: At least 90% of the total on-orbit instrument complement will be operational during their design lifetime.

Annual Performance Goal (3Y31): Successfully disseminate Earth Science data to enable our science research and applications goals and objectives. Success will equate to meeting 4 of 5 performance indicators.

Performance Indicator: Make available ESE acquired data and information on Earth's atmosphere, land and/or oceans to users within 3-5 days of their request.

Performance Indicator: Increase by 20 - 30% the total volume of data acquired by and available from NASA for its research programs compared to FY 2002. (This equates to a maximum of 1170 terabytes)

Performance Indicator: Maintain satisfactory support for the number of distinct NASA ESE data and information center customers compared to FY 2002. (This equates to 2,019,600 users).

Performance Indicator: Enable production of and distribute scientifically valid data sets from the Aqua mission.

Performance Indicator: User Satisfaction: Maintain or improve the overall level of ESE data center customer satisfaction as measured by User Working Group surveys.

Annual Performance Goal (3Y32): Safely operate airborne platforms to gather remote and *in situ* earth science data for process and calibration/validation studies.

Performance Indicator: Support and execute seasonally dependent coordinated research field campaigns within two-weeks of target departure with the aid of airborne and sub-orbital platforms, as scheduled at the beginning of the fiscal year.

Verification and Validation

While performance indicators are noted in order to demonstrate significant scientific progress toward the annual performance goal, the ESE will also rely on external expert review. The Earth System Science and Applications Advisory Committee (ESSAAC) of the NASA Advisory Council will conduct an annual assessment of the ESE near-term science objectives. It will provide a qualitative progress measurement (Green, Yellow, or Red). "Green" will indicate that the objective was met; "Yellow" will indicate a concern that an objective was not fully accomplished; and "Red" will indicate that events occurred that prevented or severely impaired the accomplishment of the objective. The assessment will include commentary to clarify and supplement the qualitative measures.

The ESSAAC is a committee of the NASA Advisory Council under the Federal Advisory Committee Act, and comprises outside scientific and technical experts from academia, industry and other government agencies. ESSAAC meets at least twice a year to review plans and progress in the ESE. After the end of each fiscal year, the ESE will provide to ESSAAC a self-assessment in each of the relevant objectives, highlighting performance against the metrics in the Performance Plan for that year. ESSAAC will deliberate internally and render its own assessment, which may confirm or modify the ESE self-assessment. The ESSAAC assessment will be reported in the Performance Report for that year. This process will be repeated annually.

The ESE will regularly review performance objectives as part of an existing monthly review process. Tracking current performance on a monthly basis for each specific FY 2003 annual performance goal enables the ESE to institute measures to ensure improvement and progress toward meeting its strategic goals.

MULTI-YEAR PERFORMANCE TREND

Earth Science

***New objectives were developed in FY 2002. The APGs can be mapped to the following new objectives:**
Objective (1A): Discern and describe how the Earth is changing.
Objective (1B): Identify and measure the primary causes of change in the Earth system.
Objective (1C): Determine how the Earth system responds to natural and human-induced changes
Objective (1D): Identify the consequences of change in the Earth system for human civilization.
Objective (IE): Enable the prediction of future changes in the Earth system.

Strategic Objective: Understand the causes and consequences of land-cover/land-use change

	FY 99	FY 00	FY01
Annual Performance Goal and APG #	Collect near-daily measurements of ocean color (index of ocean productivity from which calculations of ocean update of carbon are made). (Y3). Refresh the global archive of 30m land imagery from Landsat 7, two to three times per year. A single global archive has not been constructed since late 1970's. This will include a 15m panchromatic band (Y1). Collect near-daily global measurements of the terrestrial biosphere (index of terrestrial photosynthetic processes from which calculations of carbon uptake are made) from instruments on TERRA (Y2).	SIMBIOS will merge MODIS ocean color data into the global ocean color time series, which began with Ocean Color Temperature Sensor (OCTS) and SeaWiFS. Use time series to understand and predict response of the marine ecosystem to climate change. Make data set available via the Goddard DAAC (0Y4). Continue the ocean color time series with 60% global coverage every 4 days (0Y3). Continue the development of a global land-cover/use change data set based on Landsat and EOS instrument, at seasonal refresh rate (0Y1). Continue to collect near-daily global measurements of the terrestrial biosphere (index of terrestrial photosynthetic processes from which calculations of carbon uptake are made) from instruments on TERRA (0Y2). Produce near-real-time fire monitoring and impact assessment based on Landsat and EOS inventory and process monitoring to provide an observational foundation for monitoring change in ecosystem productivity and disturbance. Post near-real-time assessments on a web site for quick access by researchers and regional authorities (0Y7).	Increase understanding of the dynamics of the global carbon cycle by developing, analyzing and documenting multi-year data sets and meeting at least 3 of 4 performance indicators in this research area (1Y3). Explain the dynamics of global carbon cycle by building improved models and prediction capabilities and meeting 2 of 2 performance indicators in this research area (1Y4).
APG Assessment	Yellow	0Y4 was yellow. 0Y3, 0Y1, 0Y2, and 0Y7 were green.	TBD

Strategic Objective: Understand the causes and consequences of land-cover/land-use change (continued)

	FY 02	FY 03	FY 03 Cont'd
Annual Performance Goal and APG #	Increase understanding of global ecosystem change by meeting at least 3 of 4 performance indicators (2Y3). Increase understanding about the changes in global land cover and land use and their causes by meeting at least 2 of 3 performance indicators (2Y8). Increase understanding of how ecosystems respond to and affect global environmental change and affect the global carbon cycle by meeting at least 4 of 5 performance indicators (2Y11). Increase understanding of the consequence of land cover and land use change for the sustainability of ecosystems and economic productivity by meeting at least 2 of 3 performance indicators (2Y17). Increase understanding of the consequences of climate and sea level changes and increased human activities on coastal regions by meeting 2 of 2 performance indicators (2Y18).	Increase understanding of global ecosystems change. Next set of indicators to measure progress toward answering this question will be given in the FY04 plan. Last set of indicators and associated progress was presented in FY02 performance plan. An assessment of progress toward answering this question will be published FY03 report. (3Y3). Increase understanding about the changes in global land cover and land use and their causes. Next set of indicators to measure progress toward answering this question will be given in the FY04 plan. Last set of indicators and associated progress was presented in FY02 performance plan. An assessment of progress toward answering this question will be published in the FY03 report. (3Y8). Increase understanding of how ecosystems respond to and affect global environmental change and affect the global carbon cycle. Next set of indicators to measure progress toward answering this question will be given in the FY04 plan. Last set of indicators and associated progress was presented in FY02 performance plan. An assessment of progress toward answering this question will be published in the FY03 report. (3Y11). Increase understanding of the consequence of land cover and land use change for the sustainability of ecosystems and economic productivity. Next set of indicators to measure progress toward answering this question will be given in the FY04 plan. Last set of indicators and associated progress was presented in FY02 performance plan. An assessment of progress toward answering this question will be published in the FY03 report. (3Y17).	Increase understanding of the consequences of climate and sea level changes and increased human activities on coastal regions. Next set of indicators to measure progress toward answering this question will be given in the FY04 plan. Last set of indicators and associated progress was presented in FY02 performance plan. An assessment of progress toward answering this question will be published in the FY03 report. (3Y18).
APG Assessment	TBD	TBD	TBD

Strategic Objective: Understand the causes and consequences of land-cover/land-use change (continued)

	FY 02	FY 03	
Annual Performance Goal and APG #			
APG Assessment	TBD		

***New objectives have been developed for FY 2002. The APGs can be mapped to the following new objectives:**

Objective (1A): Discern and describe how the Earth is changing.
Objective (1B): Identify and measure the primary causes of change in the Earth system.
Objective (1C): Determine how the Earth system responds to natural and human-induced changes
Objective (1D): Identify the consequences of change in the Earth system for human civilization.
Objective (IE): Enable the prediction of future changes in the Earth system.

Strategic Objective: Objective: Predict seasonal-to-interannual climate variations

	FY 99	FY 00	FY01
Annual Performance Goal and APG #	TRMM will begin the second of a 3-year sequence of instantaneous measurements of rainfall rates and monthly accumulations in the global tropics. This will be the first measurement of global tropical rainfall. Current uncertainty is 50 percent. TRMM data will reduce uncertainty to 10 percent. (Y4). QuikScat to provide 25km resolution wind speed & direction measurements over at least 90% of the ice-free oceans every two days. Resolution increases by a factor of two, and a 15% increase of coverage over previous measurement (Y5).	Establish a benchmark for global and regional rainfall measurements by combining TRMM measurements with measurements from other sources. Create maps of the diurnal cycle of precipitation for the first time. Combine the existing ten-year data set with TRMM measurements to validate climate models and demonstrate the impact of rainfall on short-term weather forecasting. Distribute through the Goddard DAAC for ease of access to science and operational users (0Y9). Develop/improve methods to couple state-of-the-art land surface and sea ice models to a global coupled ocean-atmosphere model and use to predict regional climactic consequences of El Nino or La Nina occurrence in the tropical Pacific. Results of research will be published in the open literature and provided to NOAA's National Climate Prediction Center and the U.S. Navy's Fleet Numeric Prediction Center. Ultimate goal: develop a capability to significantly improve the prediction for seasonal-to-interannual climate variations and their regional climate consequences. The main focus is on North America (0Y10).	Increase understanding of the dynamics of global water cycle by developing, analyzing, and documenting multi-year data sets and meeting 2 of 2 performance indicators in this research area. (1Y5). Explain the dynamics of global water cycle by building improved models and prediction capabilities and meeting at least 2 of 3 performance indicators in this research area (1Y6).
APG Assessment		Green	TBD

Strategic Objective: Objective: Predict seasonal-to-interannual climate variations (continued)

	FY 02	FY 03	FY 03 Cont'd
Annual Performance Goal and APG #	Increase understanding of global precipitation, evaporation and how the cycling of water is changing by meeting at least 3 of 4 performance indicators (2Y1). Increase understanding of global ocean circulation and how it varies on interannual, decadal, and longer time scales by meeting 2 of 2 performance indicators (2Y2). Increase understanding of how climate variations induce changes in the global ocean circulation by meeting at least 4 of 6 performance indicators (2Y12) Increase understanding of variations in local weather, precipitation and water resources and how they relate to global climate variation by meeting 2 of 2 performance indicators (2Y16) Increase understanding of the extent that weather forecast duration and reliability can be improved by new space-based observations, data assimilation and modeling by meeting at least 2 of 3 performance indicators (2Y19). Increase understanding of the extent that transient climate variations can be understood and predicted by meeting at least 4 of 5 performance indicators (2Y20).	Increase understanding of global precipitation, evaporation and how the cycling of water through the earth system is changing. Next set of indicators to measure progress toward answering this question will be given in the FY04 plan. Last set of indicators and associated progress was presented in FY02 performance plan. An assessment of progress toward answering this question will be published in the FY03 report. (3Y1). Increase understanding of global ocean circulation and how it varies on interannual, decadal, and longer time scales.(3Y2). Increase understanding of how climate variations induce changes in the global ocean circulation by meeting at least 2 of 3 performance indicators (3Y12) Increase understanding of variations in local weather, precipitation and water resources and how they relate to global climate variation. Next set of indicators to measure progress toward answering this question will be given in the FY04 plan. Last set of indicators and associated progress was presented in FY02 performance plan. An assessment of progress toward answering this question will be published in the FY03 report. (3Y16) Increase understanding of the extent that weather forecast duration and reliability can be improved by new space-based observations, data assimilation and modeling. Next set of indicators to measure progress toward answering this question will be given in the FY05 plan. Last set of indicators and associated progress was presented in FY02 performance plan. An assessment of progress toward answering this question will be published in the FY03 report. (3Y19)	Increase understanding of the extent that transient climate variations can be understood and predicted. Next set of indicators to measure progress toward answering this question will be given in the FY05 plan. Last set of indicators and associated progress was presented in FY02 performance plan. An assessment of progress toward answering this question will be published in the FY03 report. (3Y20).
APG Assessment	TBD	TBD	

Strategic Objective: Objective: Predict seasonal-to-interannual climate variations (continued)

	FY 99	FY 00	FY01
Annual Performance Goal and APG #		Measure production and radiative properties of aerosols produced by biomass burning in Africa based on SAFARI 2000 (field experiment) and EOS instruments. Includes extensive international participation. This burning is estimated to contribute one-half of global atmospheric aerosols (0Y11). Launch the NASA-CNES Jason-1 mission. This follow-on to TOPEX/ Poseidon is to achieve a factor-of-four improvement in accuracy in measuring ocean basin-scale sea-level variability. This is 1 order of magnitude better than that specified for TOPEX/Poseidon. (0Y12). Generate the first basin-scale high-resolution estimate of the state of the Pacific Ocean as part of the international Global Ocean Data Assimilation Experiment (GODAE) (0Y47).	
APG Assessment	Blue, green, yellow or red	0Y11 was green. 0Y12 was yellow 0Y47 was green.	

	FY 02	FY 03	
Annual Performance Goal and APG #			
APG Assessment	TBD	TBD	

***New objectives have been developed for FY 2002. The APGs can be mapped to the following new objectives:**

Objective (1A): Discern and describe how the Earth is changing.
Objective (1B): Identify and measure the primary causes of change in the Earth system.
Objective (1C): Determine how the Earth system responds to natural and human-induced changes
Objective (1D): Identify the consequences of change in the Earth system for human civilization.
Objective (IE): Enable the prediction of future changes in the Earth system.

Strategic Objective: Identify natural hazards, processes, and mitigation strategies

	FY 99	FY 00	FY01
Annual Performance Goal and APG #	The Enterprise will provide the technology and instruments to create the first digital topographic map of 8o percent of Earth's land surface, everything between 60°N and 56°S. SRTM will be ready to launch in September 1999. (Y6). Use GPS array in southern California to monitor crustal deformation on a daily basis with centimeter precision; initiate installation of the next 100 stations. Data will be archived at JPL and run in models, with results given to the California Seismic Safety Commission and FEMA. (Y7). Use GPS data to test improved algorithms for sounding the atmosphere with the occulted GPS signal. Data will be archived at JPL and results published in science literature. (Y8).	Use Southern California Global Positioning System (GPS) array data to understand the connection between seismic risk and crustal strain leading to Earthquakes (0Y37). Develop models to use time-varying gravity observations for the first time in space (0Y38). Demonstrate the utility of spaceborne data for floodplain mapping with the Federal Emergency Management Agency (0Y39). Develop an automatic volcano cloud/ash detection algorithm employing EOS data sets for use by the Federal Aviation Administration (0Y40).	Increase understanding of the dynamics of the Earth's interior and crust by developing, analyzing, and documenting multi-year data sets and meeting 2 of 2 performance indicators in this research area (1Y11). Explain the dynamics of the Earth's interior and crust by building improved models and prediction capabilities and meeting 2 of 2 performance indicators in this research area (1Y12).
APG Assessment	Green	Green	TBD

Strategic Objective: Identify natural hazards, processes, and mitigation strategies (continued)

	FY 02	FY 03	
Annual Performance Goal and APG #	Increase understanding of the motions of the Earth, the Earth's interior, and what information can be inferred about the Earth's internal processes by meeting at least 3 of 4 performance indicators (2Y6). Increase understanding of the Earth's surface and how it is transformed and how such information can be used to predict future changes by meeting at least 4 of 5 performance indicators (2Y9).	Increase understanding of the motions of the Earth, the Earth's interior, and what information can be inferred about the Earth's internal processes. Next set of indicators to measure progress toward answering this question will be given in the FY05 plan. Last set of indicators and associated progress was presented in FY02 performance plan. An assessment of progress toward answering this question will be published in the FY03 report. (3Y6). Increase understanding of the Earth's surface and how it is transformed and how such information can be used to predict future changes. Next set of indicators to measure progress toward answering this question will be given in the FY05 plan. Last set of indicators and associated progress was presented in FY02 performance plan. An assessment of progress toward answering this question will be published in the FY03 report. (3Y9).	
APG Assessment	TBD	TBD	

***New objectives have been developed for FY 2002. The APGS can be mapped to the following new objectives:**

Objective (1A): Discern and describe how the Earth is changing.
Objective (1B): Identify and measure the primary causes of change in the Earth system.
Objective (1C): Determine how the Earth system responds to natural and human-induced changes
Objective (1D): Identify the consequences of change in the Earth system for human civilization.
Objective (IE): Enable the prediction of future changes in the Earth system.

Strategic Objective: Detect long-term climate change, causes, and impacts.

	FY 99	FY 00	FY01
Annual Performance Goal and APG #	MODIS, MISR, ASTER, CERES (TERRA instruments) will begin to conduct daily observations of cloud properties such as extent, height, optical thickness and particle size. Data will be distributed through the Goddard DAAC (Y9). TERRA will map aerosol formation, distribution and sinks over the land and oceans (Y10). The TERRA instrument will achieve a 40-percent reduction in the uncertainty in Earth's radiation balance (that is improved angular models leading to an estimated error reduction in regional-scale monthly average net radiation of about 50 percent. (Y11).	Complete the collection of satellite data needed for the 17-year cloud climatology being developed under the International Satellite Cloud Climatology Project. Data will be used to improve the understanding and modeling of role of clouds in climate. Data will be available in the Goddard DAAC (0Y13). Continue the development of the global aerosol climatology data set and analysis of this climatology in climate models. Data will be available in the Goddard DAAC (0Y14). Provide for the continuation of the long-term, precise measurement of the total solar irradiance with the launch of EOS ACRIM (0Y15). Acquire, through a Radarsat repeat of Antarctic Mapping Mission conducted in Sept.-Oct. 1997, a second set of high-resolution radar data over all of Antarctica for comparison with baseline data set acquired in 1997, to identify changes on the ice sheet (0Y16). Publish the first detailed estimates of thickening/thinning rates for all major ice drainage basins of Greenland ice sheet derived from repeated airborne laser-altimetry surveys. Measures represent the baseline data set to compare with early GLAS data (July 2001 launch) (OY17).	Increase understanding of the dynamics of long term climate variability by developing, analyzing, and documenting multi-year data sets and meeting at least 2 of 3 performance indicators in this research area (1Y7). Explain the dynamics of long term climate variability by building improved models and prediction capabilities and meeting at least 3 of 4 performance indicators in this research (1Y8).
APG Assessment	Yellow	All were green	TBD

Strategic Objective: **Detect long-term climate change, causes, and impacts (continued)**

	FY 02	FY 03	
Annual Performance Goal and APG #	Increase understanding of change occurring in the mass of the Earth's ice cover by meeting at least 3 of 4 performance indicators (2Y5). Increase understanding of the effects of clouds and surface hydrologic processes on climate change by meeting at least 4 of 5 performance indicators (2Y10). Increase understanding of global sea level and how it is affected by climate change by meeting at least 2 of 3 performance indicators (2Y14). Increase understanding of the extent that long-term climate trends can be assessed or predicted by meeting at least 4 of 5 performance indicators (2Y21).	Increase understanding of change occurring in the mass of the Earth's ice cover by meeting at least 3 of 4 performance indicators (3Y5). Increase understanding of the effects of clouds and surface hydrologic processes on climate change. Next set of indicators to measure progress toward answering this question will be given in the FY04 plan. Last set of indicators and associated progress was presented in FY02 performance plan. An assessment of progress toward answering this question will be published in the FY03 report. (3Y10). Increase understanding of global sea level and how it is affected by climate change. (3Y14). Increase understanding of the extent that long-term climate trends can be assessed or predicted. Next set of indicators to measure progress toward answering this question will be given in the FY05 plan. Last set of indicators and associated progress was presented in FY02 performance plan. An assessment of progress toward answering this question will be published in the FY03 report. (3Y21). Increase understanding of extent that future concentrations of carbon dioxide and methane and impacts on climate can be predicted. Next set of indicators to measure progress toward answering this question will be given in the FY05 plan. Last set of indicators and associated progress was presented in FY02 performance plan. An assessment of progress toward answering this question will be published in the FY03 report. (3Y23)	
APG Assessment	TBD	TBD	

Strategic Objective: Detect long-term climate change, causes, and impacts (continued)

	FY 99	FY 00	FY01
Annual Performance Goal and APG #		Initiate a program of airborne mapping of layers within the Greenland ice sheet to decipher the impact of past climate variation of polar regions (0Y18). Develop a remote-sensing instrument/technique for ocean surface salinity measurements from aircraft. Goal: to improve measurement accuracy to ` order of magnitude better than available in FY98. The ultimate goal is the capability to globally measure sea surface salinity from space (0Y19). Continue to improve the design and sophistication of a global climate system model, including use of higher resolution, to make it a state-of-the-art climate system model for projecting the climatic consequences at the regional level. Improvement will be manifested in increased resolution from added computing power and better numerical representations (0Y20).	
APG Assessment	Blue, green, yellow or red	All were green	

	FY 02	FY 03	
Annual Performance Goal and APG #			
APG Assessment			

***New objectives have been developed for FY 2002. The APGs can be mapped to the following new objectives:**

Objective (1A): Discern and describe how the Earth is changing.
Objective (1B): Identify and measure the primary causes of change in the Earth system.
Objective (1C): Determine how the Earth system responds to natural and human-induced changes
Objective (1D): Identify the consequences of change in the Earth system for human civilization.
Objective (IE): Enable the prediction of future changes in the Earth system.

Strategic Objective: Understand the causes of variation in atmospheric ozone concentration and distribution.

	FY 99	FY 00	FY01
Annual Performance Goal and APG #	TOMS data will be used for new retrieval methods to collect and analyze three new data products, including surface ultraviolet, tropospheric aerosols, and tropospheric columns. With SBUV/2 data, TOMS will make a continuous 20-year data set for total ozone-measuring effectiveness of Montreal Protocol. New and extended data products will be made available on TOMS web site. (Y12). Complete initiation of the full Southern Hemisphere Additional Ozonesonde network to obtain the first-ever climatology of upper tropospheric ozone in the tropics (Y14). With data from other atmospheric ozone programs, continue the detailed multi-aircraft study of troposphere chemistry over the tropical Pacific Ocean, especially the contribution of long-range transport of air from South America and Africa to unpolluted areas. Complete the field measurements phase of PEM-Tropics-B (rainy season) with an improved payload that has resulted from an initiative to develop a smaller, lighter payload with equal or better performance than PEM-Tropics-A (dry season). Results will be fully analyzed and published. (Y15).	Implement the SAGE III Ozone Loss and Validation Experiments. Measurements will be made from October 1999 to March 2000 in the Arctic/high-latitude region from the NASA DC-8, ER-2, and balloon platforms. Will acquire correlative data to validate SAGE III data and assess high-latitude ozone loss (0Y22). (Green) Complete the analysis and publication of the PEM-Tropics-B field experiment (0Y23). (Green) Complete the Troposphere Chemistry aircraft instrument size and weight reductions (by ~40%) initiative (0Y24). (Green) Complete the planning for major new 2001 airborne/unmanned aerospace vehicle mission that will use a smaller Troposphere Chemistry aircraft instrument (0Y25).	Increase understanding of the dynamics of atmospheric composition by developing, analyzing, and documenting multi-year data sets and meeting at least 4 of 5 performance indicators in this research area (1Y9). Explain the dynamics of atmospheric chemistry by building improved models and prediction capabilities and meeting at least 2 of 3 performance indicators in this research area (1Y10).
APG Assessment	Yellow	All were green.	TBD

Strategic Objective: Understand the causes of variation in atmospheric ozone concentration and distribution (continued)

	FY 02	FY 03	FY04
Annual Performance Goal and APG #	Increase understanding of stratospheric ozone changes, as the abundance of ozone-destroying chemicals decreases and new substitutes increases by meeting 2 of 2 performance indicators (2Y4). Increase understanding of trends in atmospheric constituents and solar radiation and the role they play in driving global climate by meeting at least 3 of 4 performance indicators (2Y7). Increase understanding of stratospheric trace constituents and how respond to change in climate and atmospheric composition by meeting 2 of 2 performance indicators (2Y13). Increase understanding of the effects of regional pollution on the global atmosphere, and the effects of global chemical and climate changes on regional air quality by meeting at least 4 of 5 performance indicators (2Y15). Increase understanding of the extent that future atmospheric chemical impacts on ozone and climate can be predicted by meeting at least 2 of 3 performance indicators (2Y22).	Increase understanding of stratospheric ozone changes, as the abundance of ozone-destroying chemicals decreases and new substitutes increases by meeting 2 of 2 performance indicators (3Y4). Increase understanding of trends in atmospheric constituents and solar radiation and the role they play in driving global climate by meeting at least 4 of 5 performance indicators (3Y7). Increase understanding of stratospheric trace constituents and how respond to change in climate and atmospheric composition by. (3Y13). Increase understanding of the effects of regional pollution on the global atmosphere, and the effects of global chemical and climate changes on regional air quality by meeting at least 4 of 5 performance indicators (3Y15). Increase understanding of the extent that future atmospheric chemical impacts on ozone and climate can be predicted by meeting at least 2 of 3 performance indicators (3Y22).	
APG Assessment	TBD	TBD	

Strategic Objective: Understand the causes of variation in atmospheric ozone concentration and distribution (continued)

	FY 99	FY 00	FY01
Annual Performance Goal and APG #	Use SAGE III to improve the collection and analysis of measurements provided by SAGE II, and add: nitrogen trioxide and chlorine dioxide measures; additional wavelength sampling to directly measure and retrieve aerosols throughout the troposphere; and, higher spectral resolution (Y13). With data from other atmospheric ozone programs, measure surface levels of chlorine-and bromine-containing chemical compounds addressed in the Montreal Protocol to document decreasing concentrations of regulated compounds and increasing concentrations of replacement compounds. Analyses will be provided to researchers supporting the WMO assessment process. (Y16). APGs Y13 and Y16 are linked to FY00-FY03 APGs (see previous pages).		
APG Assessment	Yellow		

	FY 02	FY 03	FY04
Annual Performance Goal and APG #			
APG Assessment			

FY 2002-2003 Enterprise-Wide Supporting Activities/FY 99-01 Objective: Successfully launch spacecraft

	FY 99	FY 00	FY01
Annual Performance Goal and APG #	The Enterprise will successfully launch three spacecraft within 10% of budget on average (Y35).	Launch three spacecraft and deliver two instruments for international launches within 10% of budget on average (0Y36).	Successfully develop, have ready for launch, and operate instruments on a least two spacecraft within 10 percent of their schedules and budget to enable Earth Science research and applications goals and objectives (1Y1).
APG Assessment	Yellow	Green	TBD

	FY 02	FY 03	FY 04
Annual Performance Goal and APG #	Successfully develop, have ready for launch, and operate instruments on at least two spacecraft to enable Earth Science research and applications goals and objectives (2Y29).	Successfully develop one spacecraft and have ready for launch. Operate instruments on orbiting spacecraft to enable Earth Science research and applications goals and objectives. (3Y30).	
APG Assessment	TBD	TBD	

FY 2002-2003 Enterprise-Wide Supporting Activities/FY 99-01 Objective: Implement open, distributed, and responsive data system architectures

	FY 99	FY 00	FY01
Annual Performance Goal and APG #	Make available data on prediction, land surface, and climate to users within 5 days (Y17). Increase the volume of data archived by 10% compared to FY97 (target = 139 terabytes). Goddard has been collecting trend data since FY94. (Y18). Increase the number of distinct customers by 20% compared to FY97 (target = 839,000). Goddard has been collecting trend data since FY94 (Y19). Increase products delivered from the DAACs by 10% compared to FY97 (target = 3.8 million). Goddard has been collecting trend data since FY94 (Y20).	EOSDIS make available data on prediction, land surface, and climate to users within five days (0Y26). EOSDIS will double the volume of data archived compared to FY98 (0Y27). EOSDIS will increase the number of distinct customers by 20% compared to FY98 (0Y28). EOSDIS will increase products delivered from the DAACs by 10% compared to FY98 (0Y29).	Successfully disseminate Earth Science data to enable our science research and applications goals and objectives by meeting all performance indicators in this research area (1Y2).
APG Assessment	Blue	All were blue.	TBD

	FY 02	FY 03	FY 04
Annual Performance Goal and APG #	Successfully disseminate Earth Science data to enable our science research and applications goals and objectives. Success will equate to meeting 4 of 5 performance indicators (2Y30). Safely operate airborne platforms to gather remote and in situ earth science data for process and calibration/validation studies (2Y31).	Successfully disseminate Earth Science data to enable our science research and applications goals and objectives. Success will equate to meeting 4 of 5 performance indicators (3Y31). Safely operate airborne platforms to gather remote and in situ earth science data for process and calibration/validation studies (3Y32).	
APG Assessment	TBD	TBD	

<u>Strategic Objective</u>: Stimulate public interest in and understanding of Earth system science and courage young scholars to consider careers in science and technology/FY 99-01 Objective: Increase public understanding of Earth system science through education and outreach.

	<u>FY 99</u>	**<u>FY 00</u>**	**<u>FY01</u>**
Annual Performance Goal and APG #	Award 50 new graduate student research grants and 20 early career postdoctoral fellowships in Earth Science. (Y21). Conduct over 300 teacher workshops to train teachers in use of Earth Science Enterprise education products (Y22). Increase number of schools participating in GLOBE from to 8,000, from 5,900 in FY98, a 35-percent increase; increase participating countries from 70 in FY98 to 72 (Y23).	Award 50 new graduate student research grants and 20 early career fellowships in Earth Science (0Y30). Conduct at least 300 workshops to train teachers in use of ESE education products (0Y31). Increase number of schools participating in GLOBE to 10,500, a 30% increase over FY99; increase participating countries to 77 (from 72). (0Y32).	Increase public understanding of Earth system science through formal and informal education by meeting at least 3 of 4 performance targets in this area (1Y18).
APG Assessment	Green	0Y30 was green. 0Y31 was blue. 0Y32 was yellow.	TBD

	<u>FY 02</u>	**<u>FY 03</u>**	**<u>FY 04</u>**
Annual Performance Goal and APG #	Share NASA's discoveries in Earth science with the public to enhance understanding of science and technology (2Y24).	Share the excitement of NASA's scientific discoveries and the practical benefits of earth science to the public in promoting understanding of science and technology in service to society. Success will equate to meeting 3 of 4 performance targets. (3Y25).	
APG Assessment	TBD	TBD	

<u>Strategic Objective</u>: Develop advanced technologies to reduce the cost and expand the capability for scientific Earth observation/FY 99-01 Objective: Develop and transfer advanced remote-sensing technologies.

	<u>FY 99</u>	**<u>FY 00</u>**	**<u>FY01</u>**
Annual Performance Goal and APG #	Annually advance at least 25% of funded instrument technology developments one TRL (Y30). Demonstrate a new capability to double the calibration quality for moderate-resolution land imagery. (Y28). Annually transfer at least one technology development to a commercial entity for operational use (Y29).	Advance at least 25% of funded instrument technology development one TRL to enable future science missions and reduce their total cost (0Y35). Achieve a 50% reduction in mass for future land imaging instruments (0Y33). Transfer at least one technology development to a commercial entity for operational use (0Y34).	Achieve success with timely development and infusion of technologies. Enable future science missions by increasing technology readiness for mission concepts to reduce their total cost. Do this by meeting at least 3 of 4 performance indicators for this advanced technology area (1Y13).
APG Assessment	Green	0Y35 was blue 0Y33 and 0Y34 were green	TBD

	<u>FY 02</u>	**<u>FY 03</u>**	**<u>FY 04</u>**
Annual Performance Goal and APG #	Successfully develop and infuse technologies that will enable future science measurements, and/or improve performance and reduce the cost of existing measurements. Increase the readiness of technologies under development, advancing them to a maturity level where they can be infused into new missions with shorter development cycles (2Y25).	Successfully develop and infuse technologies that will enable future science measurements, and/or improve performance and reduce the cost of existing measurements. Increase the readiness of technologies under development, retiring risks and advancing them to a maturity level where they can be infused into new missions with shorter development cycles. Success will equate to meeting 3 of 4 performance indicators. (3Y26).	
APG Assessment	TBD	TBD	

Strategic Objective: Develop advanced information systems for processing, archiving, accessing, visualizing, and communicating Earth science data. (Introduced in FY02)

	FY 99	FY 00	FY 01
Annual Performance Goal and APG #			
APG Assessment			

	FY 02	FY 03	FY 04
Annual Performance Goal and APG #	Develop hardware/software tools to demonstrate high-end computational modeling to further our understanding and ability to predict the dynamic interaction of physical, chemical and biological processes affecting the earth (2Y26). Develop baseline suite of multidisciplinary models and computational tools leading to scalable global climate simulations. (2Y27)	Develop hardware/software tools to demonstrate high-end computational modeling to further our understanding and ability to predict the dynamic interaction of physical, chemical and biological processes affecting the earth. Success will equate to meeting 2 of 3 performance indicators. (3Y27) Develop baseline suite of multidisciplinary models and computational tools leading to scalable global climate simulations. (3Y28)	
APG Assessment	TBD	TBD	

Strategic Objective: Demonstrate scientific and technical capabilities to enable the development of practical tools for public and private-sector decision makers/FY 99-01 Strategic Objective: Extend the use of Earth Science research for regional, state, and local applications

	FY 99	FY 00	FY01
Annual Performance Goal and APG #	Establish at least five Regional Earth Science Applications Centers (RESACs) (Y31). Complete solicitation for seven co-operative agreements with State and local governments in areas of land use planning, land capability analysis, critical areas management, and water resource management (Y33). Establish at least eight new projects, with USDA, in the areas of vegetation mapping and monitoring, risk and damage assessment, resources management and precision agriculture (Y32).	At least one of seven Regional Earth Science Applications Center (RESAC) becomes self-sustaining. Continue funding for the remaining centers (0Y41). Develop two new validated commercial information products as a result of verification and validation partnerships with industry (0Y46). Implement at least five joint applications research projects/partnerships with State and local governments in remote –sensing applications (0Y43).	Provide regional decision-makers with scientific and applications products/tools by meeting at least 7 of 8 performance indicators for this applications research area (1Y14). Improve access to and understanding of remotely sensed data and processing technology by meeting 3 of 3 performance indicators in this area (1Y15).
APG Assessment	Blue	0Y41 was yellow 0Y46 and 0Y43 were green	TBD

	FY 02	FY 03	FY 04
Annual Performance Goal and APG #	Provide regional decision-makers with scientific and applications products and tools (2Y23).	Provide regional decision-makers with scientific and applications products and tools by meeting 3 of 3 performance indicators. (3Y24)	
APG Assessment	TBD	TBD	

Strategic Objective: Partner with other agencies to develop and implement better methods for using remotely sensed observations in Earth system monitoring and prediction/FY 99-01 Strategic Objective: Extend the use of Earth Science research for regional, state, and local applications.

	FY 99	FY 00	FY 01
Annual Performance Goal and APG #			
APG Assessment			

	FY 02	FY 03	FY 04
Annual Performance Goal and APG #	Collaborate with other Federal and international agencies in developing and implementing better methods for using remotely sensed observations (2Y28)	Collaborate with other domestic and international agencies in developing and implementing better methods for using remotely sensed observations. Success will equate to meeting 4 of 5 performance indicators. (3Y29)	
APG Assessment	TBD	TBD	

FY 99-01 Objective: Support the development of a robust commercial remote sensing industry.

	FY 1999	FY 2000	FY 2001	FY 2002
Annual Performance Goal and APG #	Establish at least 75 commercial partnerships in "value-added" remote sensing product development; an increase from 37 over FY97 (Y34).	Focus EOCAP joint commercial applications research to develop 20 new market commercial products (e.g., oil spill containment software by EarthSat and map sheets products by ERDAS, Inc.). (0Y44). Provide three commercial sources of science data (from the data buy) for global change research and applications (0Y45). Develop two new validated commercial information products as a result of verification and validation partnerships with industry (0Y46).	Stimulate the development of a robust commercial remote sensing industry by meeting at least 4 of 5 performance indicators in this area (1Y16). Increase efficiencies in food and fiber production with the aid of remote sensing by meeting the performance indicator in this area (1Y17).	**Note: No longer a strategic objective.**
Assessment	Blue	0Y44 was yellow 0Y45 and 0Y46 were green	TBD	

FY 99-01 Strategic Objective: Make major scientific contributions to national and international environmental assessments

	FY 1999	FY 2000	FY 2001	FY 2002
Annual Performance Goal and APG #	Make significant contribution to World Meteorological Organization (WMO) Ozone Assessment by providing a lead chapter author and most of the global-scale data (Y26). Contribute model results of climate affects of measured aircraft emissions and provide report to IPCC assessment report (Y24). Make significant contributions to US. Regional/national assessments in partnership with U.S. Global Change Research Program agencies (Y25). Provide lead chapter author and most of the global-scale data and contributing researchers to the IPCC Assessment Report, sponsored by the United Nations Environment Program and WMO (Y27).	Sponsor two regional national assessment studies of environmental variations and natural resources vulnerability (0Y48). (Green) Complete the contribution to the First National Assessment of the Potential Consequences of Climate Variability and Change: provide climate scenario information, support the national synthesis, conduct several regional U.S. analyses, and provide supporting research for sector analyses. Provide information to the U.S. National Assessment Coordination Office. (0Y5). (Green)	**Note: Incorporated into science objectives in FY01 and beyond.**	
Assessment	Green	Green		

FY 99-01 Strategic Objective: Make major scientific contributions to national and international environmental assessments (continued)

	FY 1999	FY 2000	FY 2001	FY 2002
Annual Performance Goal and APG #		Conduct the first regional international assessment in South Africa: quantify the effects of climate variability and management practices on the environment, publish in open literature, and provide analyses to IPCC for their 2000 assessment. (0Y6). Provide the first global, regional and country-by country forest cover inventory in support of national and international needs research, operational and policy communities. Publish and provide to IPCC and the International Geosphere-Biosphere Program for their 2000 assessment report (0Y8).		
Assessment		0Y6 was yellow. 0Y8 was green.		

APG #	**Office of Earth Science FY 2003 Budget Link Table**	**Budget Category**	Earth Observing System	Earth Explorers	Operations	Research and Technology	Investments
3Y1	Increase understanding of global precipitation, evaporation and how the cycling of water through the earth system is changing		X		X	X	
3Y2	Increase understanding of global ocean circulation and how it varies on interannual, decadal, and longer time scales				X	X	
3Y3	Increase understanding of global ecosystems change		X			X	
3Y4	Increase understanding of stratospheric ozone changes, as the abundance of ozone-destroying chemicals decreases and new substitutes		X		X	X	
3Y5	Increase understanding of change occurring in the mass of the Earth's		X	X		X	
3Y6	Increase understanding of the motions of the Earth, the Earth's interior, and what information can be inferred about the Earth's internal			X		X	
3Y7	Increase understanding of trends in atmospheric constituents and solar radiation and the role they play in driving global climate		X			X	
3Y8	Increase understanding about the changes in global land cover and land use and their causes		X			X	
3Y9	Increase understanding of the Earth's surface and how it is transformed and how such information can be used to predict future changes		X	X		X	
3Y10	Increase understanding of the effects of clouds and surface hydrologic processes on climate change		X			X	
3Y11	Increase understanding of how ecosystems respond to and affect global environmental change and affect the global carbon cycle		X		X	X	
3Y12	Increase understanding of how climate variations induce changes in the global ocean circulation		X			X	
3Y13	Increase understanding of stratospheric trace constituents and how they respond to change in climate and atmospheric composition				X	X	
3Y14	Increase understanding of global sea level and how it is affected by climate change					X	

APG #	**Office of Earth Science FY 2003 Budget Link Table**	**Budget Category**	Earth Observing System	Earth Explorers	Operations	Research and Technology	Investments
3Y15	Increase understanding of the effects of regional pollution on the global atmosphere, and the effects of global chemical and climate changes on regional air quality		X		X	X	
3Y16	Increase understanding of variations in local weather, precipitation and water resources and how they relate to global climate variation		X		X	X	
3Y17	Increase understanding of the consequence of land cover and land use change for the sustainability of ecosystems and economic productivity		X			X	
3Y18	Increase understanding of the consequences of climate and sea level changes and increased human activities on coastal regions		X			X	
3Y19	Increase understanding of the extent that weather forecast duration and reliability can be improved by new space-based observations, data assimilation and modeling				X	X	
3Y20	Increase understanding of the extent that transient climate variations can be understood and predicted		X		X	X	
3Y21	Increase understanding of the extent that long-term climate trends can be assessed or predicted					X	
3Y22	Increase understanding of the extent that future atmospheric chemical impacts on ozone and climate can be predicted					X	
3Y23	Increase understanding of the extent that future concentrations of carbon dioxide and methane and their impacts on climate can be					X	
3Y24	Provide regional decision-makers with scientific and applications products and tools.					X	
3Y25	Share the excitement of NASA's scientific discoveries and the practical benefits of Earth science to the public in promoting understanding of science and technology in service to society					X	

APG #	**Office of Earth Science FY 2003 Budget Link Table**	**Budget Category**	Earth Observing System	Earth Explorers	Operations	Research and Technology	Investments
3Y26	Successfully develop and infuse technologies that will enable future science measurements, and/or improve performance and reduce the cost of existing measurements. Increase the readiness of technologies under development, retiring risks, and advancing them to a maturity level where they can be infused into new missions with shorter					X	
3Y27	Develop hardware/software tools to demonstrate high-end computational modeling to further our understanding and ability to predict the dynamic interaction of physical, chemical and biological					X	
3Y28	Develop baseline suite of multidisciplinary models and computational tools leading to scalable global climate simulations					X	
3Y29	Collaborate with other domestic and international agencies in developing and implementing better methods for using remotely sensed observations to support national and international assessments of climate changes and their practical consequences					X	
3Y30	Successfully develop one (1) spacecraft and have ready for launch. Operate instruments on orbiting spacecraft to enable Earth science research and applications goals and objectives		X	X		X	
3Y31	Successfully disseminate Earth Science data to enable our science research and applications goals and objectives		X			X	
3Y32	Safely operate airborne platforms to gather remote and in situ earth science data for process and calibration/validation studies					X	